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PATENT SPECIFICATION

NO DRAWINGS

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COMPLETE SPECIFICATION

Coating Process

We, MONSANTO CHEMICALS LIMITED, a British Company of Monsanto House, 10—18 Victoria Street, London, S.W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a process and apparatus for the production of refractory moulds.

Various ways of producing refractory moulds have been proposed, and one which is effective and economical in its use of starting materials is the so-called ceramic shell process. In this process there is first prepared a fusible pattern of the shape that is desired in the final casting, and a relatively thin shell of refractory is formed round the pattern. The shell is formed by a series of operations which include coating the pattern with a layer of slurry containing a finely divided refractory filler and a binding agent, for example one containing silica, and then covering the layer of slurry with a "stucco" of refractory particles. The process works well in general, although difficulties are sometimes experienced in producing well-finished mouldings having a particularly intricate shape. A new process has now been developed in which such difficulties are reduced.

The invention comprises a process for the production of a refractory mould, which comprises applying to a pattern a coating of a slurry comprising a binding agent and a refractory filler, in which the pattern is vibrated during at least part of the slurry-coating operation.

The invention also comprises an apparatus suitable for applying to a pattern a coating of a slurry comprising a binding agent and a refractory filler in the production of a refractory mould which apparatus comprises means for vibrating the pattern during at least part of a slurry-coating operation.

[*Price 4s. 6d.*]

In a preferred process according to the invention for the production of a ceramic shell mould, the pattern is dipped into a bath containing the slurry and vibrated while still submerged in the slurry.

The binding agent in the slurry used in making the coating is preferably one containing silica. Very often it is a solution of a hydrolysed organic silicate such as an ethyl silicate, or a silica sol (that is to say a colloidal solution of silica). The silica content of the binding agent is very often between 7 and 35%, such as between 10 and 30%, by weight of the binding agent, for instance about 25% by weight.

Where the binding agent is one formed by hydrolysis of an organic silicate this can be an orthosilicate but in practice is usually a condensed silicate, that is to say a mixture of polysilicates. Good results are obtained using an ethyl silicate or an isopropyl silicate, for example a mixture of silicates prepared by the reaction of silicon tetrachloride with ethyl or isopropyl alcohol containing a small proportion of water. The commercial ethyl silicate sold under the name "Silester OS" ("Silester" is a Registered Trade Mark) is particularly useful. In use the silicate is hydrolysed with up to 15% by weight of water in the presence of an acid, for instance hydrochloric acid, and a mutual solvent, for instance ethyl or isopropyl alcohol; the binding agent accordingly has an acid pH, and will often have a silica content between 7 and 35% by weighht.

The binding agent can also be a silica sol, and is preferably so where the slurry is used in applying the first refractory coating. A sol can suitably be one containing perhaps 15% to 50% of silica by weight. Good results are obtained when the concentration of silica in the sol is within the range of from 20% to 40% by weight, particularly when the concentration is about 30% by weight. The aqueous silica sols containing about 30% by weight of silica which are commercially available under

the names "Syton 2X" and "Syton P" (Syton is a Registered Trade Mark) are especially useful. Preferably the silica sol is acidified so that the binding agent has an acid pH.

The refractory filler used in making the slurry can be chosen from a wide range of refractory materials. For example it can be an aluminosilicate such as molochite, sillimanite or mullite; silicon carbide; an oxide such as silica, alumina, magnesia, or zirconia; a silicate such as ziron or forsterite; or a calcined fireclay such as for instance calcined Ayrshire or Stourbridge clays. The particle size of the filler is preferably less than 200 mesh, that is to say none of the powder is retained on a 200 mesh British Standard Sieve (BSS), and preferably the refractory should contain a significant proportion, perhaps 50 to 75% of material of particle size less than 300 mesh. The slurry can be prepared simply by mixing the powdered refractory filler a little at a time with the binding agent. A slurry of suitable viscosity can for example contain between about 30 and about 90 parts of the binder per 100 parts by weight of the refractory filler, depending mainly on the type and state of subdivision of the filler. The slurry preferably has an acid pH, for instance a pH from 1.5 to 5.0, such as about 2 or 3. An organic or inorganic acid can be present as a means of imparting an acid pH to the slurry, such as acetic, nitric, or hydrochloric acid.

As previously stated the coating of slurry is preferably applied to the pattern by dipping the pattern into a bath of the slurry although other methods are also possible, such as for example pouring the slurry into a narrow gap between a pattern and a preformed mould backing.

During the coating operation the pattern (or a runner-bar in the case of an assembly of patterns) can be supported, for example by means of a steel bar embedded therein, and a handle attached. The vibration is conveniently applied to the pattern or patterns through the supporting means, or the pattern (or a partially coated pattern as explained below) can be placed in contact with a vibration means already located within the slurry. In the latter case the vibration means can either where appropriate be completely immersed within the slurry or more conveniently can comprise a vibratable member that extends downwards into the bath of slurry or projects upwards through the bottom of the bath or through a side-wall. Where such a vibratable member passes through the bottom or a side-wall of the bath, it can be surrounded by an extensible bellows, for instance of rubber or metal, that acts as a gland. It is often found to be convenient if the apparatus comprises means for adjusting the depth of the pattern within the bath of slurry which can for example be operated by a foot-pedal control. A bellows connection for a vibratable member as mentioned above is particularly often useful where the apparatus comprises such means for adjustment. The pattern need not be vibrated during the whole of the coating operation and durations of vibration of from 10 seconds to 120 seconds have been found to be useful, particularly from 40 seconds to 80 seconds, for example 60 seconds.

The frequency of vibration is preferably greater than 10 cycles per second. A frequency in the range of 30 cycles per second to 2000 cycles per second, for example about 55 cycles per second, has been found very suitable. Very much higher frequencies, for instance up to 20 or even 50 kilocycles per second, can be employed if desired.

The amplitude of vibration depends to some extent on the size and shape of the pattern but is usually within the range 0.001 inch to 0.050 inch, preferably from 0.010 inch to 0.030 inch, for example 0.020 inch.

The vibration can be produced by any suitable machine, preferably one having means for varying the amplitude of vibration. Such machines are commercially available and are usually electromagnetically operated although other types can be utilised, for instance an electric motor-driven cam rotating against a spring-loaded pressure plate. A pneumatically operated vibration machine, for instance one employing a ball bearing blown by compressed air around a suitable race, can be employed and is very often preferred, for example where the slurry contains an organic solvent so that an electrically-operated machine might constitute a fire or explosion hazard.

It is preferable to establish good mechanical contact between the vibration means and the pattern before starting the vibration, or alternatively to make such contact while the amplitude of vibration is very small, for example less than 0.001 inch, and then increase the amplitude to the required level.

In a process according to the invention for the production of a shell mould, after the pattern has been coated with the slurry any surplus slurry is allowed to drain off; the pattern is not vibrated during draining. The remaining steps in making the shell can then follow established procedure. A layer of stucco particles is usually applied to the wet slurry, the stucco being of a refractory filler similar in principle to that used in the slurry. The particles can be applied to the moist layer of slurry covering the pattern by for example allowing the particles to fall on the slurry layer, or by immersing the coated pattern in a mass of the particles maintained in a state of agitation by means of a current of air or some other suitable gas. After application of stucco, the slurry is allowed to harden. Where a silica-containing binding agent is employed in the slurry this can if desired be done simply by drying the coating the atmosphere, but a quicker method is to cause the silica-containing binding agent in the slurry to gel by the action of a gelation

accelerator. In the instance of a hydrolysed silicate ester binder the accelerator can for example be ammonia, or an organic amine such as for instance, pyridine, piperidine, or dicyclohexylamine. Where the binder is a silica sol, the accelerator can for example be calcium carbonate, calcium chloride, sodium carbonate, magnesium oxide, magnesium carbonate, ammonium chloride, hydrochloric acid or sulphuric acid. After the first coating has been applied and hardened further coatings can be applied as required. The number of refractory coatings applied to the pattern usually varies from 2 to perhaps 12 or more. If desired the pattern can be vibrated during each slurry-coating operation, although with the later coatings this is not essential. Particularly good results are however obtained when the pattern is vibrated during at least the first two slurry-coating operations.

In general the way that a pattern is removed depends on the type of mould and the pattern. Where the pattern is fusible, as in a ceramic shell process or other lost-wax process, it can of course be melted out in a suitable way.

The process of the invention is an efficient and economic one for example for the production of high quality ceramic shell moulds capable of casting metal objects with an excellent surface finish.

The process of the invention is illustrated by the following Example.

EXAMPLE

This Example describes the production of a ceramic shell mould for casting a small metal article of intricate shape.

A slurry was prepared from 26 kilograms of zircon having a particle size less than 200 BSS mesh and 5 litres of Syton 2X (a stable silica sol containing 30% by weight of silica colloidally dispersed in water) to which had been added sufficient concentrated hydrochloric acid to give an approximately 0.1N solution (about 150 cc.).

A number of hydrocarbon wax patterns were prepared which were of generally cylindrical shape, each one having a central longitudinal hole approximately 20 millimetres in diameter with an internal screw thread of 4 millimetres pitch and 2 millimetres depth. Such patterns had previously been found very difficult to coat in a satisfactory manner.

An assembly of these wax patterns provided with a metal handle was then dipped into the slurry. With the pattern submerged in the slurry, the metal handle was connected to a portable electromagnetic vibration machine and the pattern was vibrated at a frequency of 50 cycles per second, with an amplitude of 0.020 inch for 60 seconds. After the vibration treatment the pattern was removed from the slurry and allowed to drain (without vibration) for 5 seconds. A stucco of powdered molochite of particle size such that none was retained on a 40 mesh BSS sieve but all was retained on an 80 mesh BSS sieve was then applied to the wet surface as uniformly as possible.

The coated pattern was then transferred to a chamber in which it was treated with an atmosphere containing 1% by volume of ammonia vapour for one minute. At the end of this period the refractory coating had hardened, and after allowing a further 2 minutes for the excess ammonia to evaporate, a second layer of slurry was applied with vibration as before. The process was repeated applying alternately stucco and slurry until a total of 5 layers had been built up. After exposure of the final layer to ammonia, the coated pattern was allowed to dry at room temperature.

Finally the whole assembly was placed in an autoclave and subjected to steam under pressure at a temperature of 120°C., the mould being in an inverted position so that the molten wax ran out. There was obtained a strong shell mould from which excellent castings were obtained, no casting defects being found in any of the internal threaded areas.

For the purposes of comparison the above procedure was repeated except that the vibration of the pattern while submerged in the slurry was omitted. All the resulting castings were found to be defective in that the internal threaded areas had numerous protuberances of excess metal due to imperfect mould structure.

WHAT WE CLAIM IS:—

1. A process for the production of a refractory mould, which comprises applying to a pattern a coating of a slurry comprising a binding agent and a refractory filler, in which the pattern is vibrated during at least part of the slurry-coating operation.

2. A process according to Claim 1, in which the pattern is dipped into a bath containing the slurry and vibrated while still submerged in the slurry.

3. A process according to either of Claims 1 and 2, in which the binding agent is one containing silica.

4. A process according to Claim 3, in which the binding agent is a solution of a hydrolysed organic silicate or a silica sol.

5. A process according to any of the preceding claims, in which the duration of vibration is from 40 seconds to 80 seconds.

6. A process according to any of the preceding claims, in which the frequency of vibration is in the range of 30 to 2000 cycles per second.

7. A process according to any of the preceding claims, in which the amplitude of vibration is from 0.010 inch to 0.030 inch.

8. A process according to any of the preceding claims, in which mechanical contact between the vibration means and the pattern is established before starting the vibration or while the amplitude of vibration is less than 0.001 inch, the amplitude then being increased to the required level.

9. A process according to any of the preced-

ing claims, in which a number of refractory coatings are applied to the pattern and the pattern is vibrated during at least the first two slurry-coating operations.

10. A process according to Claim 1 substantially as described in the Example.

11. An apparatus suitable for applying to a pattern a coating of a slurry comprising a binding agent and a refractory filler in the production of a refractory mould which apparatus comprises means for vibrating the pattern during at least part of a slurry-coating operation.

12. An apparatus according to Claim 11 having means for varying the amplitude of vibration.

13. An apparatus according to either of Claims 11 and 12, which comprises means for adjusting the depth of the pattern within the bath of slurry.

14. A refractory mould that has been produced by a process according to any of Claims 1 to 10.

15. A process according to any of Claims 1 to 10, in which there is used an apparatus according to Claim 13.

16. A refractory mould that has been produced by a process according to Claim 15.

17. A process of casting a metal article, in which there is used a refractory mould according to Claim 14.

18. A cast metal article that has been produced by a process according to Claim 17.

19. A process of casting a metal article, in which there is used a refractory mould according to Claim 16.

20. A cast metal article that has been produced by a process according to Claim 19.

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